

# Southern California Shelf Rockfish Hook and Line Survey



## OUTLINE

### Introduction and survey description

- Survey objective, study area, and rationale
- Survey design and site descriptions
- Fishing and biological sampling protocols

### Data collected

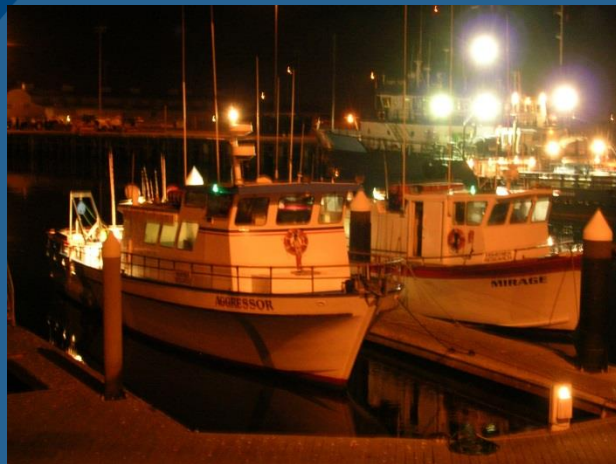
- Design and protocol-related data
- Biological data
- Ecological data

### Data Management

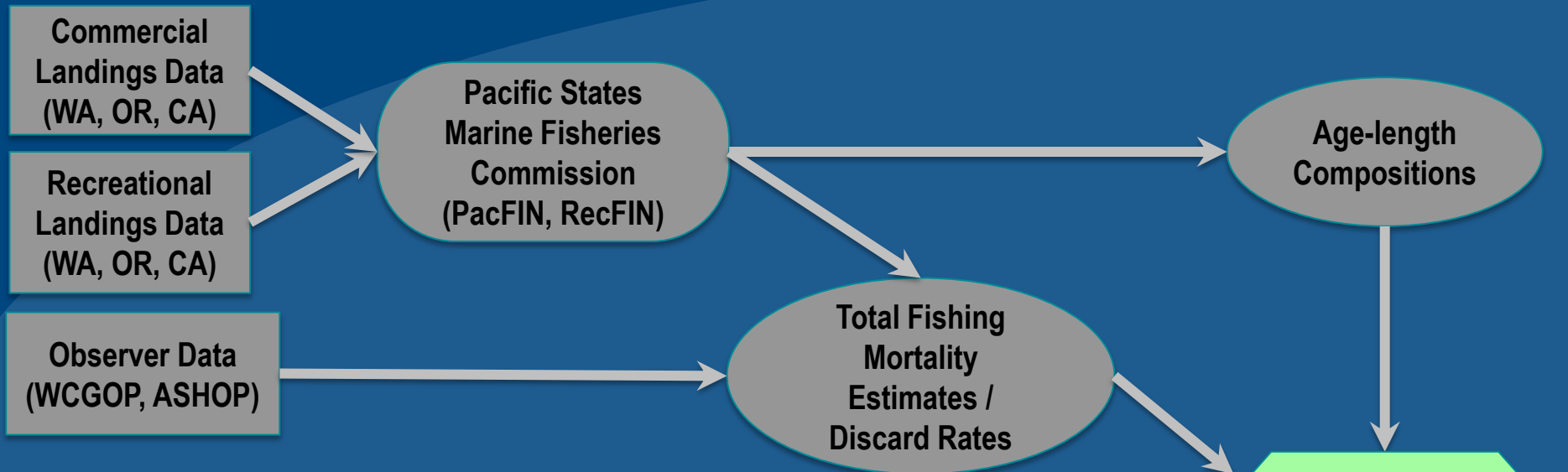
- At sea and shoreside

### Analysis and modeling

### Strengths and Challenges

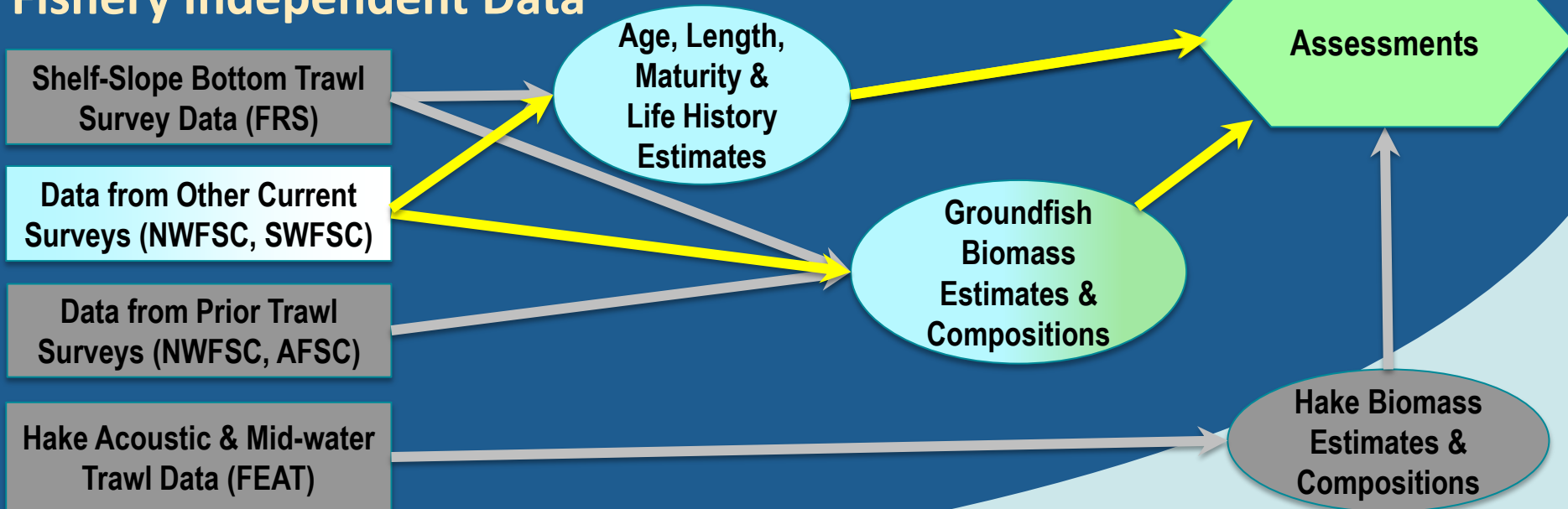


## Fishery Dependent Data



## Fishery Data Flows

### Fishery Independent Data

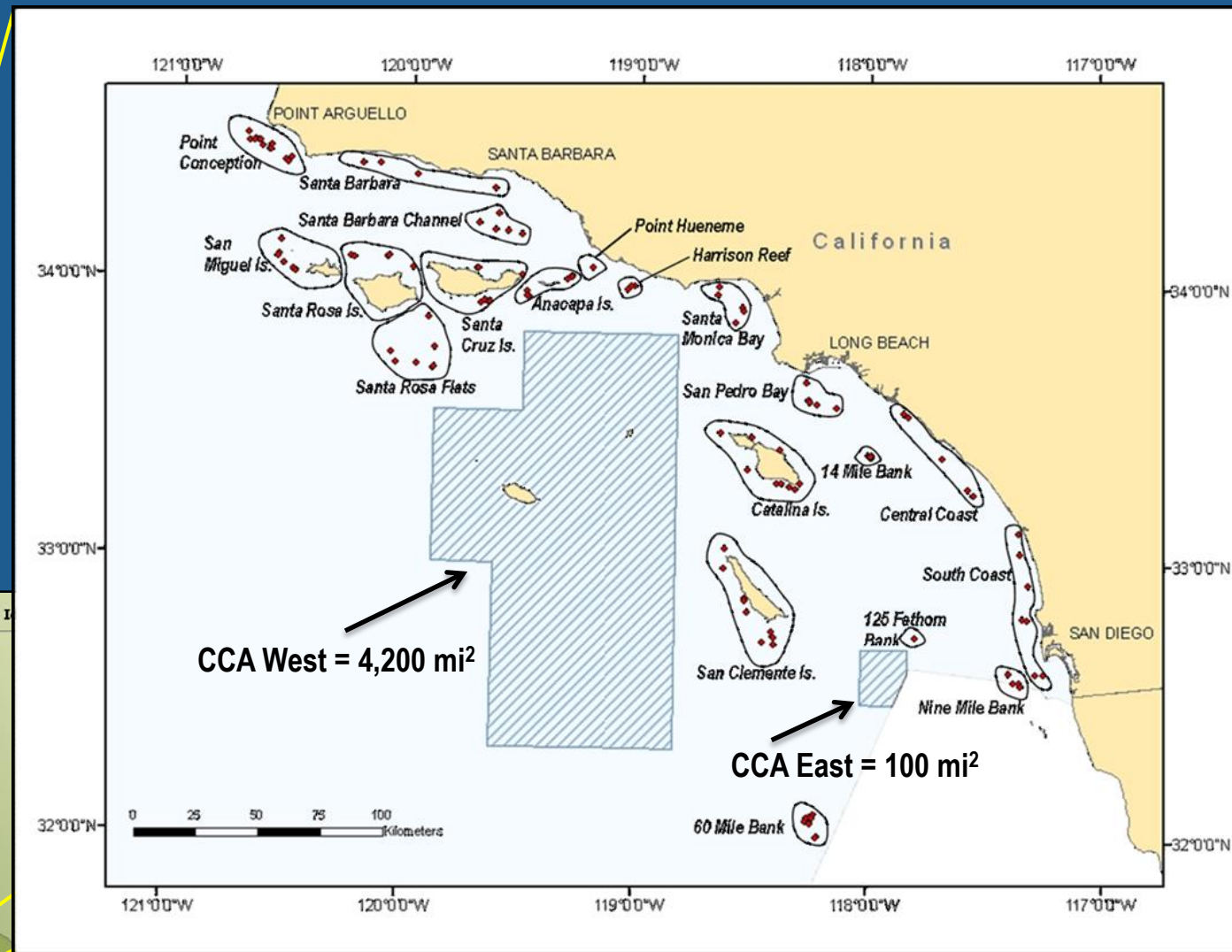


# Survey Objective

The hook and line survey is designed to complement other fishery-independent groundfish surveys by developing annual abundance indices and time series of biological information for groundfish species associated with the untrawlable habitats of the Southern California Bight for use in stock assessments.



# Survey Region: Southern California Bight (SCB)



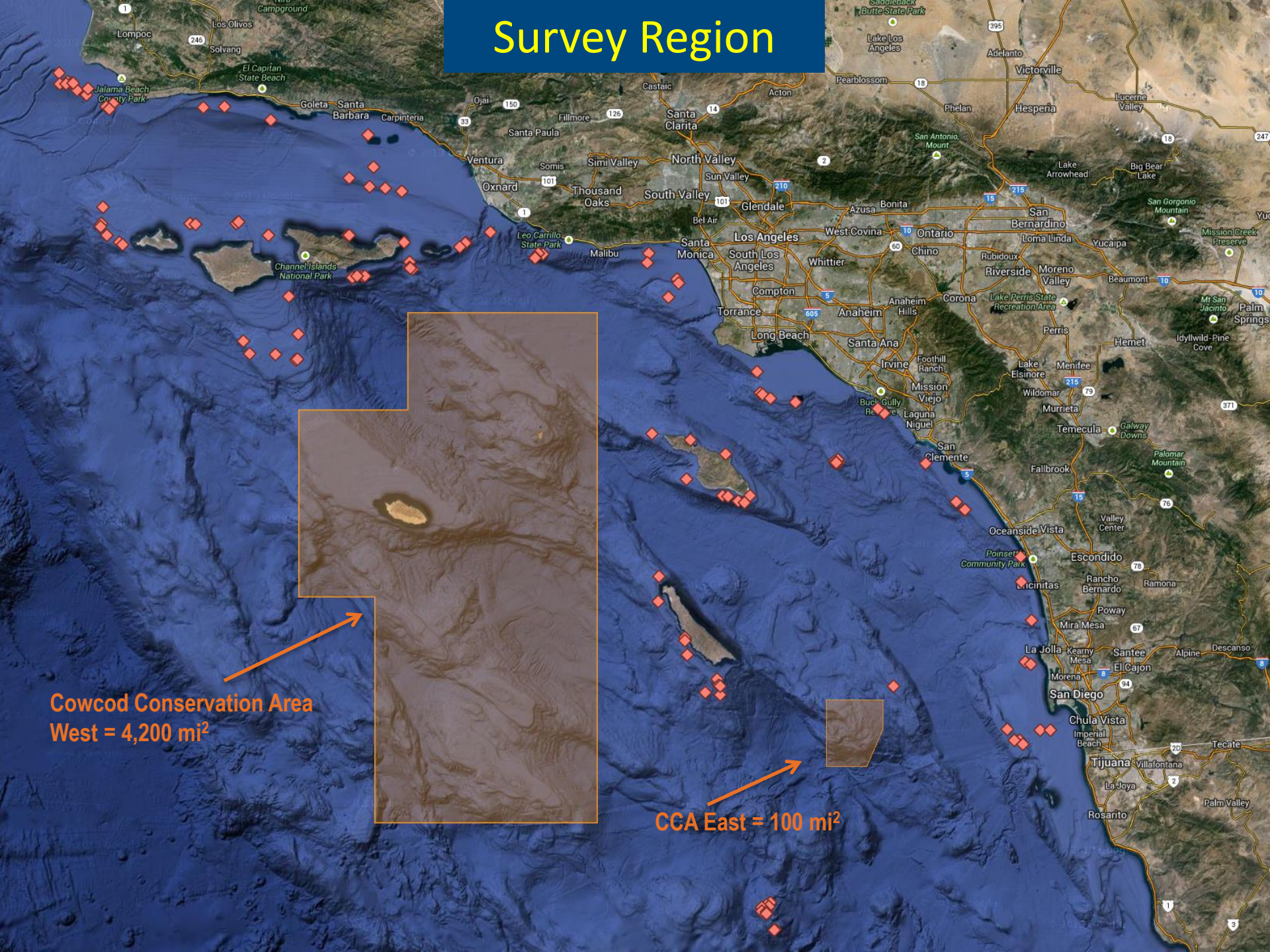
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# Survey Region

Cowcod Conservation Area  
West = 4,200 mi<sup>2</sup>

CCA East = 100 mi<sup>2</sup>







## ROCKFISH

Aurora rockfish

Bank rockfish

Black rockfish

Black/yellow rockfish

Blackgill rockfish

Blue rockfish

Bocaccio

Bronzespotted rockfish

Brown rockfish

Calico rockfish

California scorpionfish

## ROCKFISH

Canary rockfish

Chameleon rockfish

Chilipepper

China rockfish

Copper rockfish

Cowcod

Darkblotched rockfish

Dusky rockfish

Dwarf-red rockfish

Flag rockfish

Freckled rockfish

Gopher rockfish

Grass rockfish

Greenblotched rockfish

Greenspotted rockfish

Greenstriped rockfish

Halfbanded rockfish

Harlequin rockfish

Honeycomb rockfish

Kelp rockfish

## ROCKFISH

Squarespot rockfish

Starry rockfish

Stripetail rockfish

Swordspine rockfish

Tiger rockfish

Treefish

Vermilion rockfish

Widow rockfish

Yelloweye rockfish

Yellowmouth rockfish

Yellowtail rockfish

Puget Sound rockfish

90 FMP  
Species

## GRENADIERS

Pacific rattail

## MORIDS

Finescale codling



## ROCKFISH

Longspine thornyhead

Mexican rockfish

Olive rockfish

Pink rockfish

Pinkrose rockfish

Pygmy rockfish

Pacific ocean perch

Quillback rockfish

Redbanded rockfish



## FLATFISH

Arrowtooth flounder

Butter sole

Curlfin sole

Dover sole

English sole

Flathead sole

Pacific sanddab

Petrale sole

Rex sole

Rock sole

Sand sole

Starry flounder

## ROUNDFISH

Cabazon

Kelp greenling

Lingcod

Pacific cod

Pacific hake

Sablefish

## SHARKS

Big skate

California skate

Leopard shark

Longnose skate

Soupin shark

Spiny dogfish

## RATFISH

Spotted ratfish

## ROCKFISH

Rosethorn rockfish

Rosy rockfish

Rougheye rockfish

Sharpchin rockfish

Shortbelly rockfish

Shortraker rockfish

Shortspine thornyhead

Silvergray rockfish

Sunset rockfish

Speckled rockfish

Splitnose rockfish

# Survey Design

- Pilot project in 2003; annual survey cruises since 2004
- Conducted in late Sept. – early Oct.
- 2 vessels, 12 days on the water (24 vessel-days)
- Conducted aboard chartered commercial sportfishing vessels; ~ 60' in length; same 2 vessels since 2004
- Sampling gear: 5-hook vertical gangions deployed by rod and reel
- Geographic extent: Pt. Arguello to the Mexican border
- Depth range: 20 – 125 fathoms (37 – 227m)
- 121 fixed sites spread across 20 sampling areas, re-visited annually

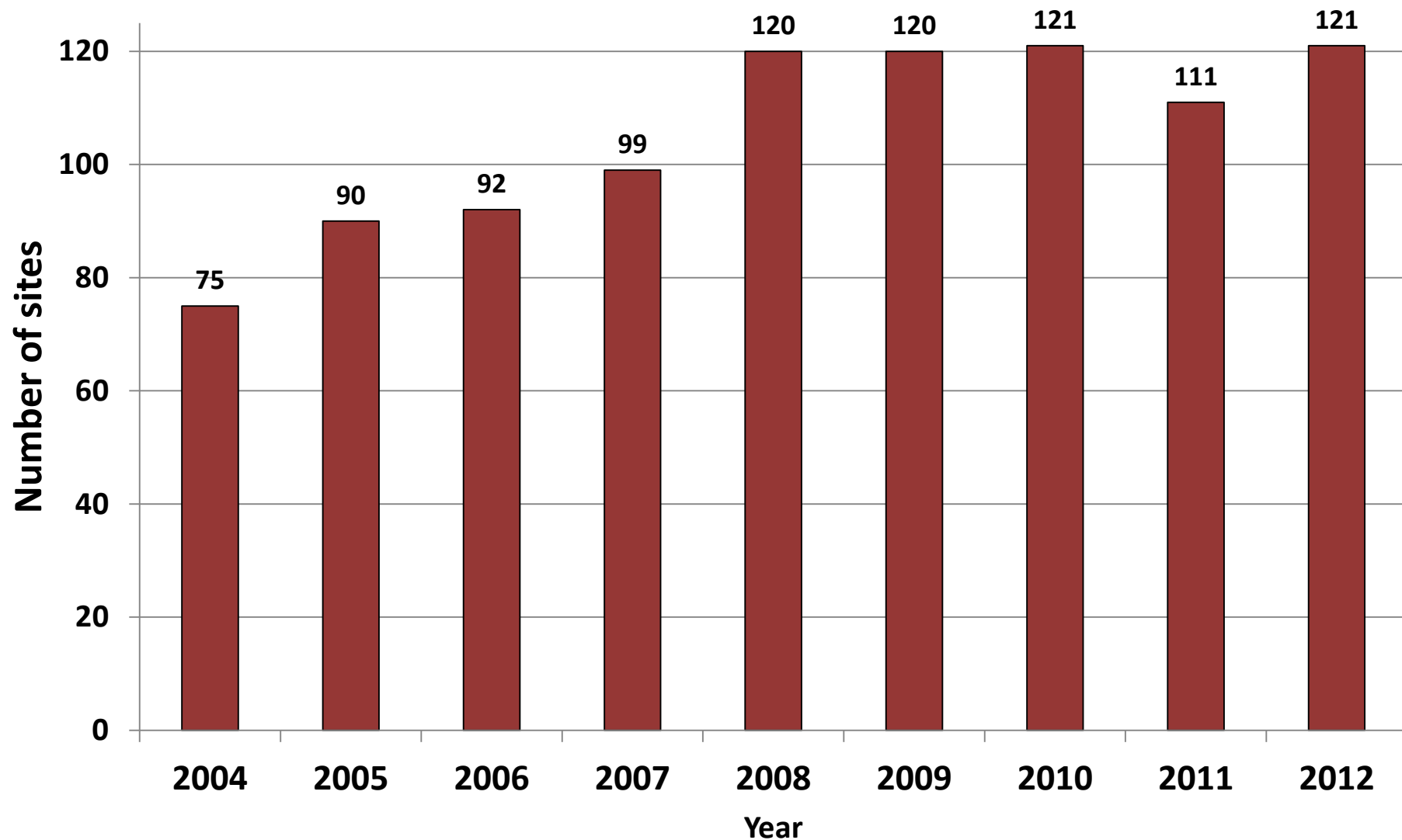






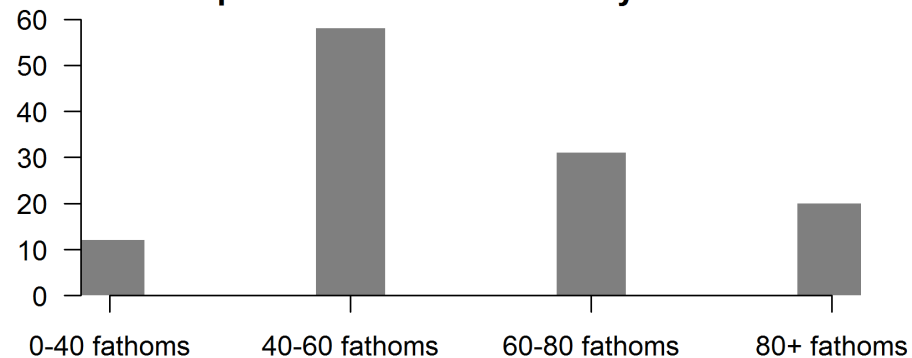


# Number of sites sampled 2004-2012

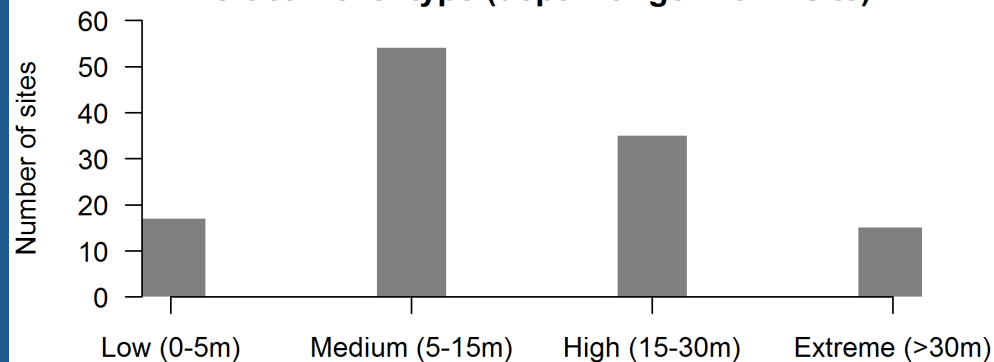


- Broad range of depths, relief, and distance from port
- Facilitates sampling a larger set of species and exploitation histories

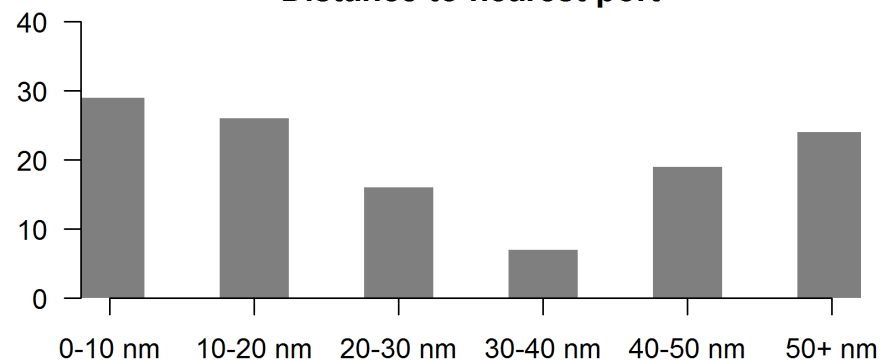
**Depth distribution of sites by stratum**



**Vertical relief type (depth range within site)**



**Distance to nearest port**





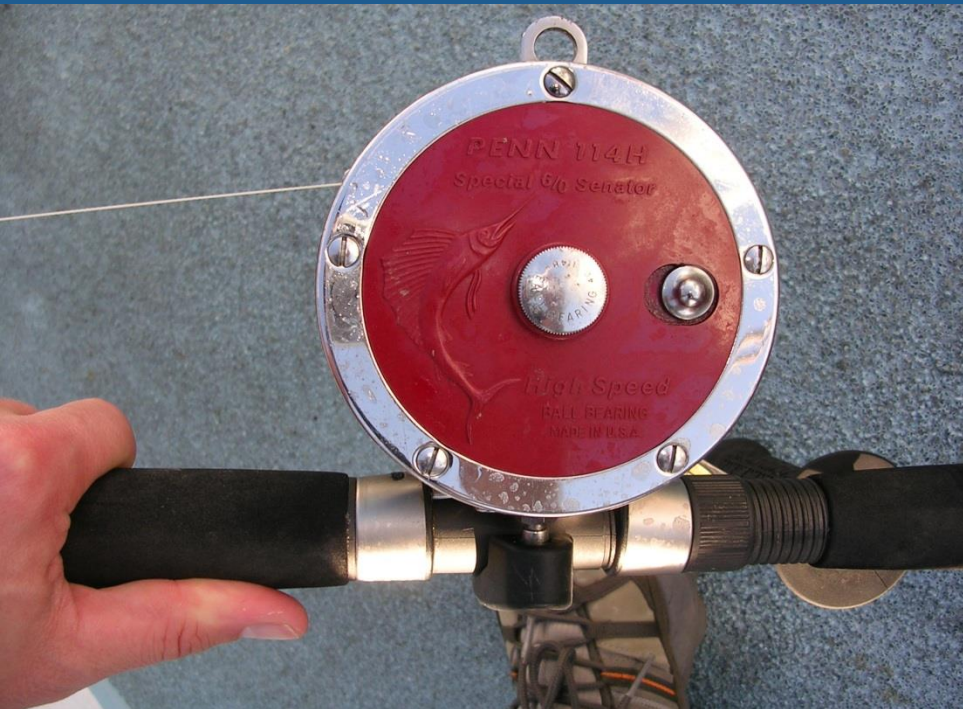
# Sampling Overview

- 3 anglers × 5 drops × 5 hooks per line = 75 hooks per site
- Captain has a 100-yd radius around site coordinates to search and target habitat or aggregations
- Each angler uses a stopwatch track 4 time waypoints
  - Bottom time, first bite time, retrieval time, and surface time
  - Maximum of 5 minutes of on-bottom or “soak time” per drop
- Daylight hours only



# Survey Gear

- Heavy duty boat rods with large-capacity reels
- Standardized equipment chosen with extensive input from the industry based on survey goals





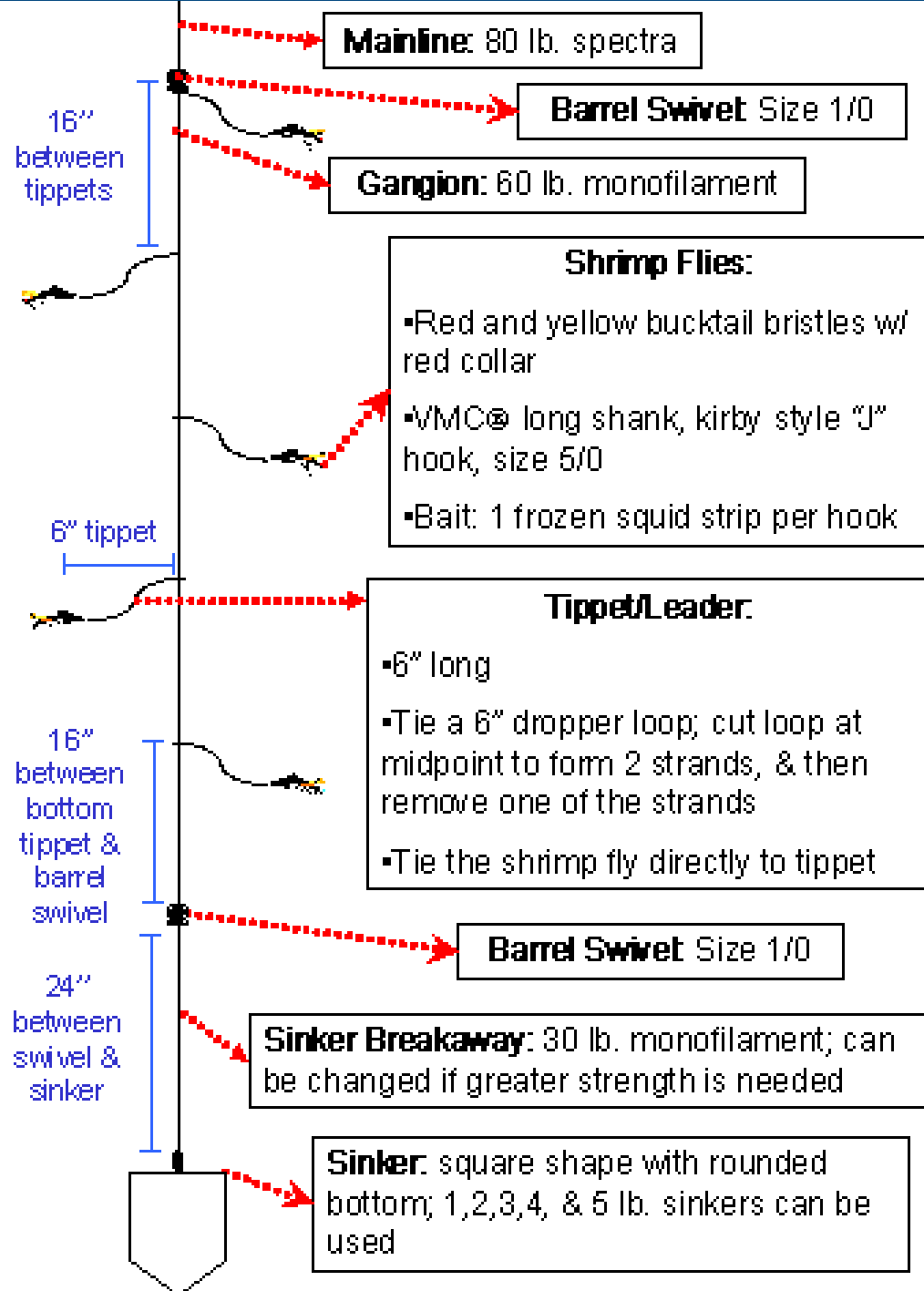
# Survey Gear:

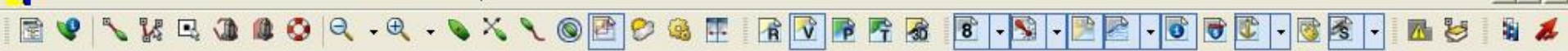
## Sampling Gangion

- Gangion also designed with industry input
- Effectively targets a wide range of demersal rockfish species

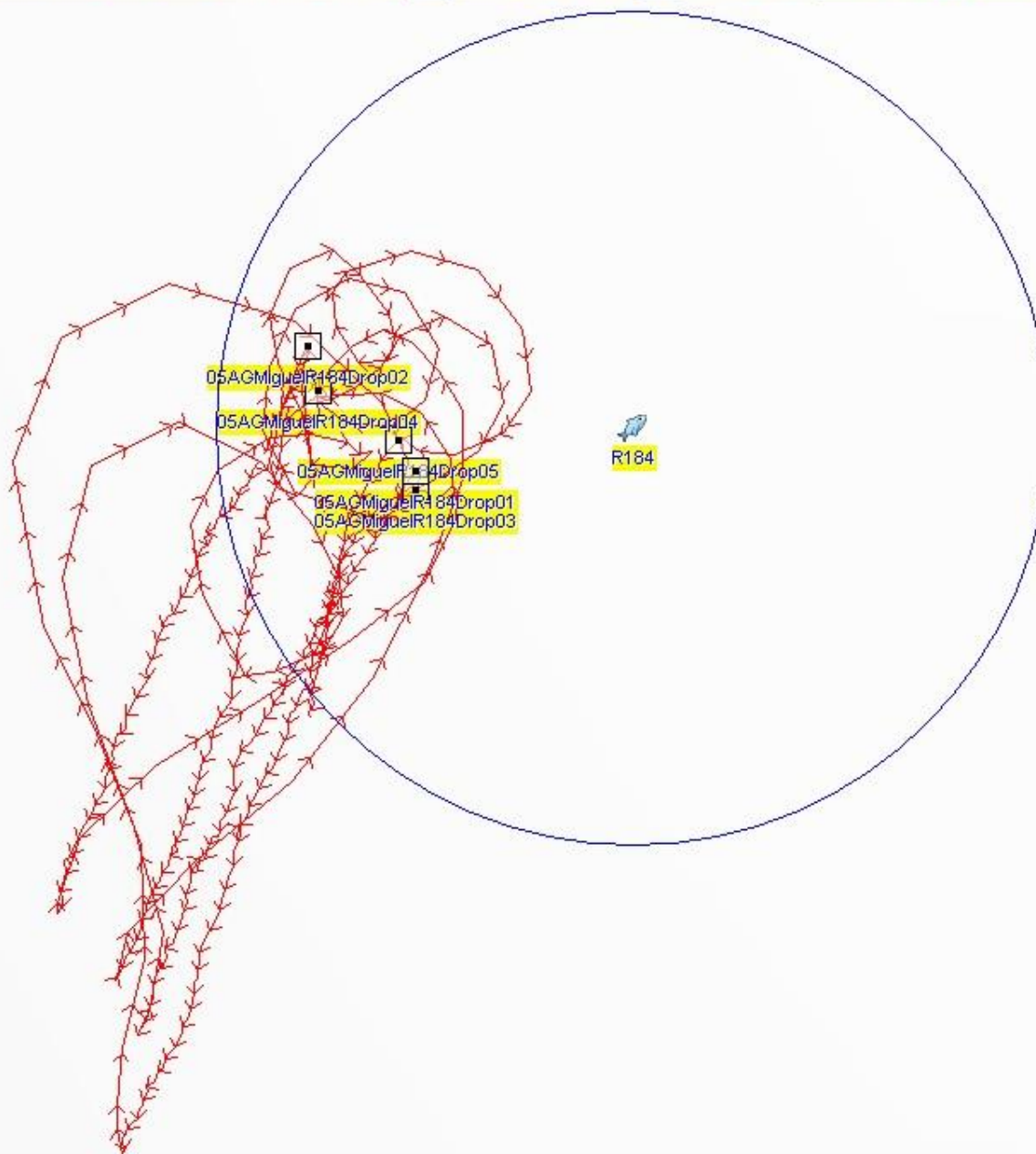
## Gear standardization

- Consistent since the initiation of the survey





N



SS Nobeltec

Lat: 47 38.662 N

Lon: 122 18.414 W

No GPS

SOG: N/A

BSP: N/A

COG: N/A

Hdg: N/A

Dpt: N/A

Wtr: N/A

Cursor Position

Lat: 34 03.601 N

Lon: 120 33.246 W

05:18:41 PM







# Biological Sampling

- Second biologist works at sampling station
- Length, weight, sex, age, and tissue sample collected from all rockfish
- Specimens for maturity analyses taken from key species
- Non-rockfish (e.g. lingcod) released alive



# Hierarchical Data Collection

→ Year

→ Vessel

→ Site

→ Drop

→ Angler

→ Hook

→ Fish





# Site Data

- Site (categorical)
- Distance to nearest port
- Swell height
- Swell direction
- Wave height
- Moon phase
- Moon % fullness
- Tide phase (ebb, flood, steady)
- Tide type (spring, neap, neither)
- Tide height
- Tidal flow (ft/hr)
- Sunrise time
- Sunset time
- Duration of solar day
- Oceanographic data (CTD)
  - Temperature
  - Salinity
  - Dissolved oxygen
  - Chlorophyll
  - Turbidity
- Qualitative observations
  - Habitat (sounder)
  - Fish aggregations (sounder)
  - Ocean and weather conditions

FRAM Hook and Line Survey

## SITE SHEET

Date: 10/2/12 Vessel: MT Site Name: 133 Set ID: 120101053  
 SCS File Index No.: 57 General Area: Clemente Day of Cruise: 10  
 FPC name: JH Recorded by: JH na/10/11

Event	Time (24 hr)	Latitude (DD MM.MMM)	Longitude (DD MM.MMM)	Depth (fth)	Sfc. Temp. °C	Wind		Drift	
						Spd. (kts)	Dir. °	Spd. (kts)	Dir. °
Drop 1	1214	32 44 663	118 24 684	53.8	21.6	10.3	242	1.0/1.0	104
Drop 2	1229	32 44 660	118 24 689	53.1	21.6	10.9	242	1.1/1.1	91
Drop 3	1242	32 44 668	118 24 644	55.3	21.6	10.6	247	1.1/1.1	103
Drop 4	255	32 44 649	118 24 681	54.3	21.6	13.1	247	1.2/1.3	90
Drop 5	1310	32 44 644	118 24 680	54.8	21.5	13.6	244	1.3/1.3	98
CTD Cast	1326	32 44 668	118 24 671	53.8					

Salinity	Temperature	Depth	DO <sub>2</sub> (SBE 43)	DO <sub>2</sub> (Andera)	Fluorescence	Turbidity
33.35 (psu)	12.4 (°C)	66.7 (m)	5.30 (ml/l)	4.68 (ml/l)	1.05 (µg/l)	16.4 (NTU)

Wind		Drift		Sea state			Moon phase	
spd. (kts)	dir.°	spd. (kts)	dir.°	swell ht. (ft)	swell dir.°	wave ht. (ft)	(% full & phase)	
0	285°	0	85°	2	265°	1.5	95 %	
> 0-1		> 0 - 0.1					New moon	
1-3		0.1 - 0.5		Tide			Sfc. Temp. (°F)	Waxing crescent
4-6		0.5 - 1.0		Station: Wilson Cove			21.6 70.88	First quarter
7-10		1.0 - 1.5		Distance: 16.9 nm				Waxing gibbous
11-16		1.5 - 2.0		Phase: ebb flood steady			Sunrise (24 hr)	Full moon
17-21		2.0 - 2.5		Type: spring neap neither			0650	Waning gibbous
22-27		2.5 - 3.0		Height: First Mid Last			Sunset (24 hr)	Third quarter
28-33		3.0 - 3.5		(ft) 4.6 4.2 3.6			1837	Waning crescent
> 34		> 3.5						

\* For wind & swell direction, enter the direction in compass degrees FROM which they originate; for drift direction, enter the direction in compass degrees TO which the boat is moving

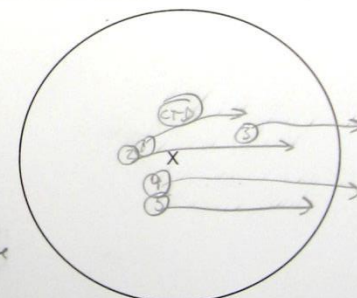
Habitat: Nice, big rock; rocky bottom

Fishfinder / aggregations: Fair fishing

Ocean / weather: Sunny, warm, breezy; low swell w/ some wind chop

General:

Site Avg  
 DSpd 1.2  
 DDir 82  
 SST 21.6  
 WSpd 11.7  
 WDir 244



Indicate the position of each drop using "1", "2", etc. and the direction of the drifts using arrows.



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## Drop Data

- Drop number (1-5)
- Time of day
- Position (GPS)
- Depth
- Vessel drift speed & direction
- Wind speed & direction
- Surface temperature
- Sinker weight

## Angler Data

- Angler position (A,B,C)
- Angler identity
- Gear performance
- Time waypoints
  - Gear on bottom
  - First bites
  - Begin retrieval
  - Gear at surface
- Effective fishing time (calculated)
- Time to first bite (calculated)

## Hook Data

- Hook position (1-5)
- Hook result
  - Fish
  - Bait back
  - No bait
  - Missing hook
  - Multiple hook



# Biological Data

- Fish identified to species
- Angler, drop, hook no.
- Fork length
- Weight
- Sex
- Otolith
- Fin clip (for genetic analyses)
- Ovary (as needed for maturity projects)
- Other special projects

Date: 9/24/10 Vessel: Alacran Site Name: 374 Set ID: 10010006  
SCS File Index No.: 006 General Area: CONC Day of Cruise: 1  
FPC name: Horns Recorded by: Matt / KRM

Species	Angler	Drop No.	Hook No.	Weight (kg)	Length (cm)	Sex	Otolith No.*	Fin Clip No.*	Special Project(s)	Re-leased
gusset	C	1	1	0.66	32	F	G021	G020		<input type="checkbox"/>
vermillion	A	1	1	1.62	46	M	V247	V247		<input type="checkbox"/>
"	B	1	4	0.30	25	M	V248	V246		<input type="checkbox"/>
"	B	1	2	0.28	25	F	V249	V249	ovary	<input type="checkbox"/>
"	B	1	3	.46	31	M	V250	V250		<input type="checkbox"/>
"	C	2	1	.86	36	M	V251	V251		<input type="checkbox"/>
"	C	2	3	1.08	41	M	V252	V252		<input type="checkbox"/>
"	A	2	4	.40	29	M	V253	V253		<input type="checkbox"/>
"	C	2	5	.84	37	F	V254	V254	ovary	<input type="checkbox"/>
Bolacero	A	1	4	1.14	45	F	B044	B044		<input type="checkbox"/>
"	B	1	1	.40	32	F	B045	B045		<input type="checkbox"/>
verm	C	3	3	.38	27	F	V255	V255	ovary	<input type="checkbox"/>
"	C	3	1	.22	23	M	V256	V256		<input type="checkbox"/>
"	A	3	4	1.76	47	M	V257	V257		<input type="checkbox"/>
"	C	3	4	1.92	48	M	V258	V258		<input type="checkbox"/>
"	B	3	1	1.32	43	M	V259	V259		<input type="checkbox"/>
"	C	3	5	0.24	25	F	V260	V260	ovary	<input type="checkbox"/>
Bolacero	A	3	5	.60	38	F	B046	B046		<input type="checkbox"/>
"	A	3	4	.64	39	M	B047	B047		<input type="checkbox"/>
"	A	3	2	0.60	37	F	B048	B048		<input type="checkbox"/>
vermillion	A	4	1	1.38	43	M	V261	V261		<input type="checkbox"/>
"	C	4	2	1.66	45	M	V262	V262		<input type="checkbox"/>
"	B	5	1	1.06	37	F	V263	V263		<input type="checkbox"/>
"	A	5	1	1.71	46	M	V264	V264		<input type="checkbox"/>
"	A	5	5	0.94	38	M	V265	V265		<input type="checkbox"/>
"	A	5	4	1.18	41	M	V266	V266		<input type="checkbox"/>
"	C	5	1	1.06	40	M	V267	V267		<input type="checkbox"/>
"	A	5	3	2.04	48	F	V268	V268		<input type="checkbox"/>

\* Include the first letter of the species name before the otolith, and finclip numbers and include leading zeroes when the number < 100 (e.g., "V024", "A008", etc.)

NOTES: + wt changed to 0.24

Data checked by KRM on 9/24/10





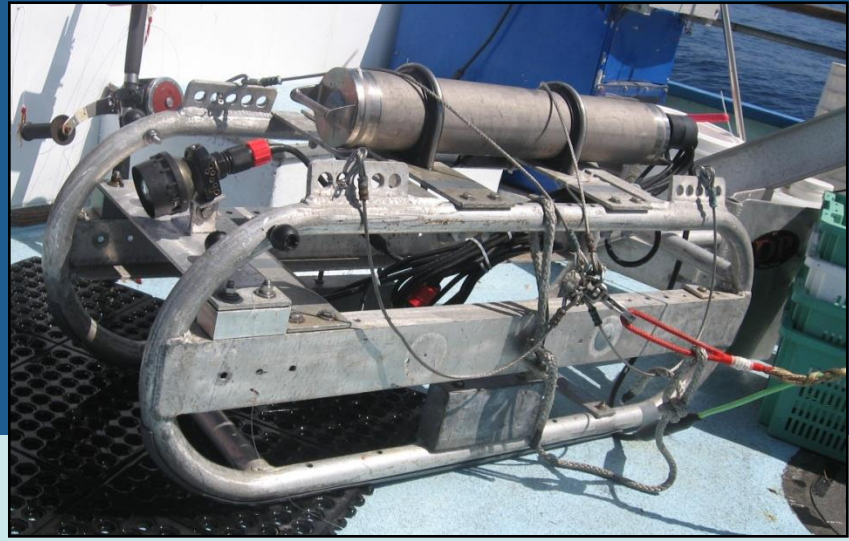
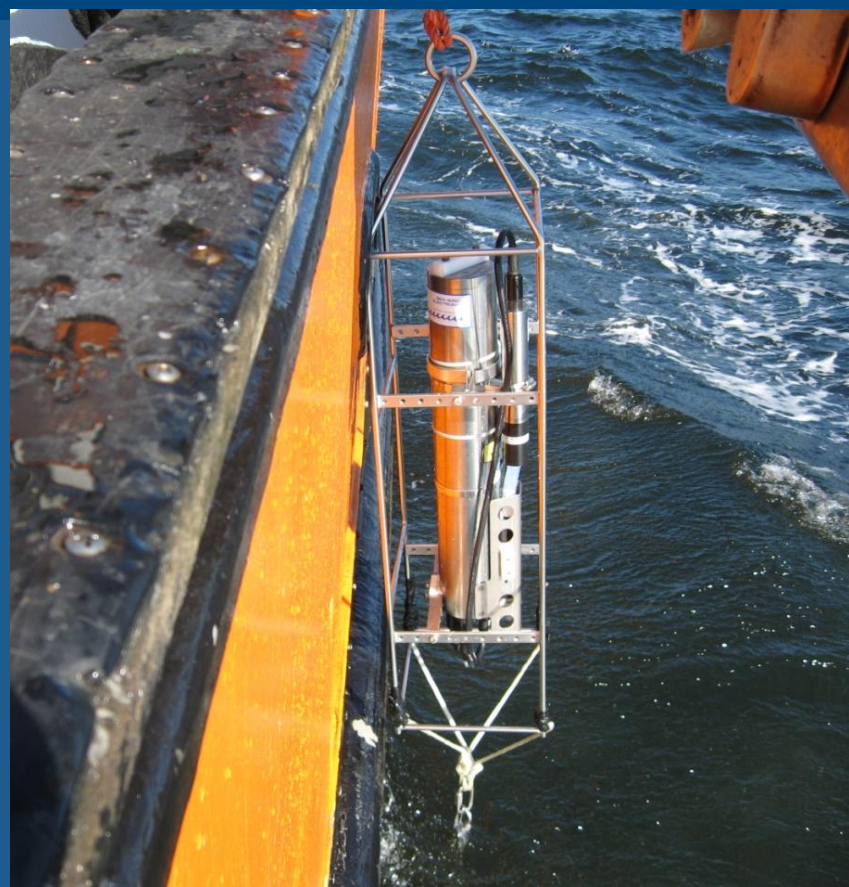
# Ecological Data

## Oceanographic profiles

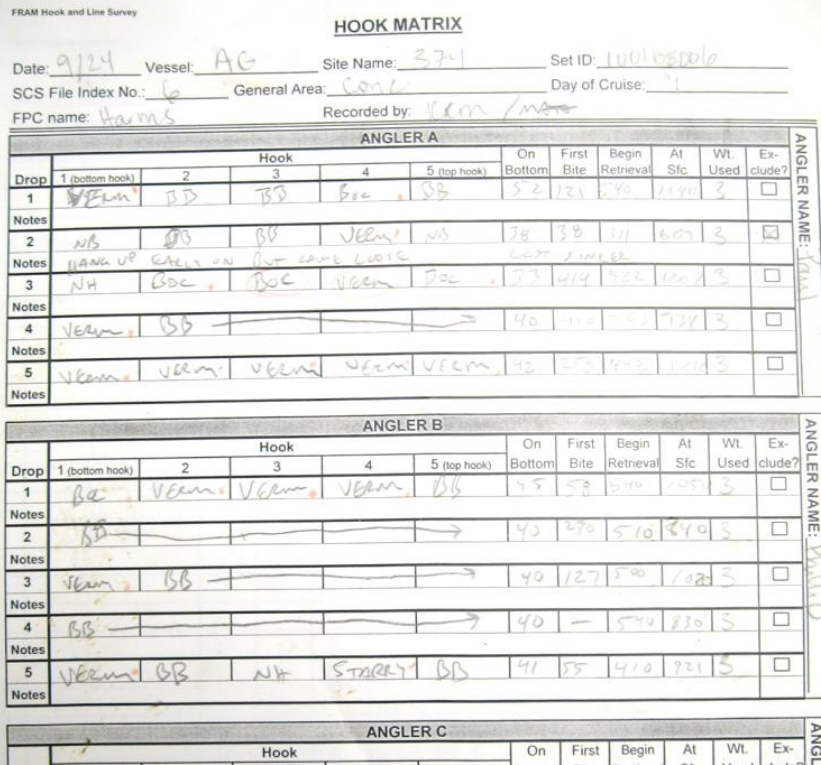
- CTD sensor suite deployed to generate a full water column profile at each site
- Data collected: temperature, salinity, dissolved oxygen, chlorophyll, turbidity

## Habitat type

- Underwater video sled deployed opportunistically to capture visual observations of the seafloor at survey sites



- At-sea QA/QC comparing paper sheets
- Shoreside manual entry into customized forms feeding an Access 2010 database
- Each site requires ~1 hour for data entry or about 3 weeks to enter all 121 sites
- Key punching errors or incorrect handwriting interpretation are uncommon but do occur





# Most frequently encountered species

Species	Total caught	% lengths	% weights	% sexed	% otoliths	% fin clips
Vermilion/Sunset Rockfish	8761	99.6%	99.6%	99.1%	97.5%	97.7%
Bocaccio	6243	99.5%	99.5%	99.3%	98.3%	98.7%
Greenspotted Rockfish	1954	99.5%	99.6%	99.1%	98.0%	98.2%
Yellowtail Rockfish	1016	95.2%	95.3%	89.0%	76.7%	95.0%
Chilipepper	714	99.4%	99.4%	96.9%	79.7%	98.7%
Speckled Rockfish	671	99.7%	99.7%	99.4%	97.2%	99.3%
Starry Rockfish	595	99.5%	99.5%	99.3%	95.8%	99.3%
Copper Rockfish	562	98.6%	98.9%	98.6%	96.8%	98.4%
Widow Rockfish	492	99.4%	99.4%	98.8%	98.8%	99.2%
Pacific sanddab	424	93.4%	93.6%	91.5%	0.0%	15.3%
Swordspine Rockfish	401	99.5%	99.5%	98.5%	90.5%	99.3%
Bank Rockfish	306	99.3%	99.3%	99.7%	99.0%	99.7%
Blue Rockfish	299	99.3%	99.3%	99.3%	98.7%	99.0%
Rosy Rockfish	287	100.0%	100.0%	97.9%	88.2%	100.0%
Lingcod	277	92.4%	93.5%	70.8%	0.0%	70.0%
Greenblotched Rockfish	245	100.0%	100.0%	99.6%	98.0%	99.6%
Halfbanded Rockfish	228	98.7%	98.7%	96.9%	91.7%	97.4%
Squarespot Rockfish	221	99.5%	99.5%	98.2%	92.8%	97.7%
Cowcod	188	100.0%	100.0%	99.5%	99.5%	99.5%

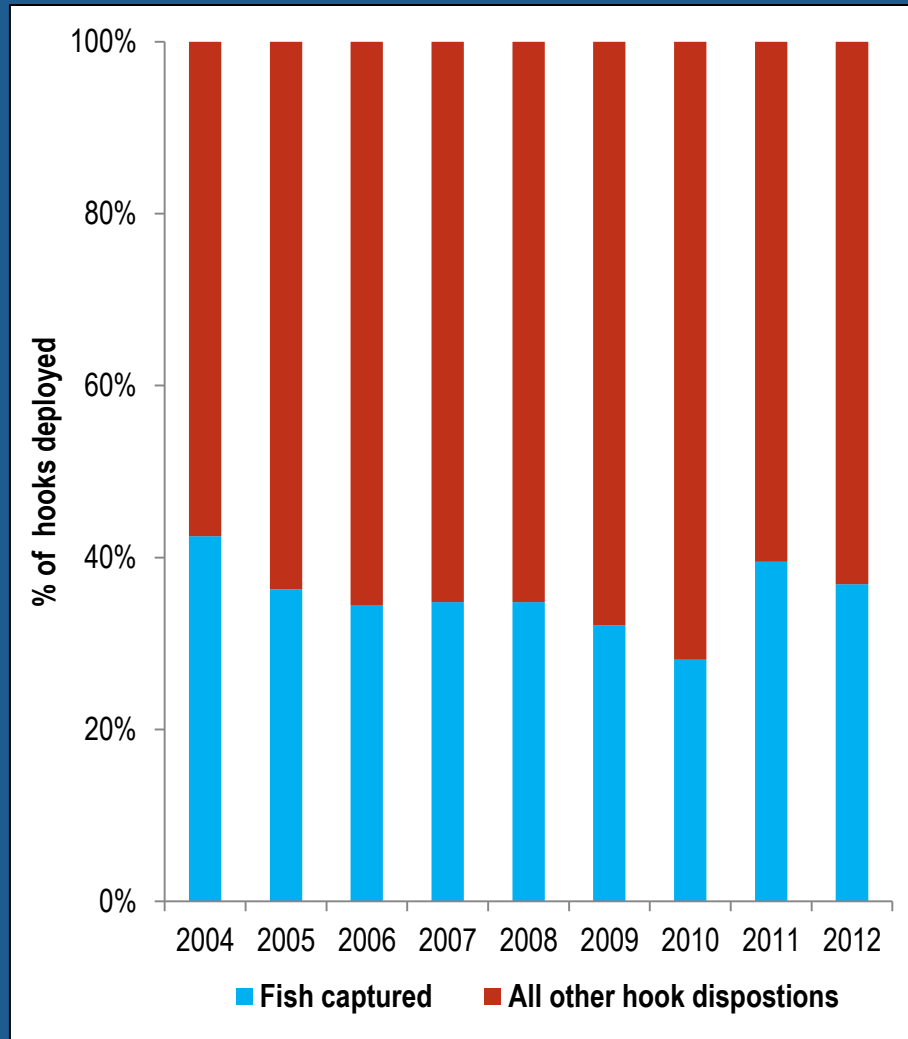
Hook and line survey data also used in the 2009 yelloweye stock assessment



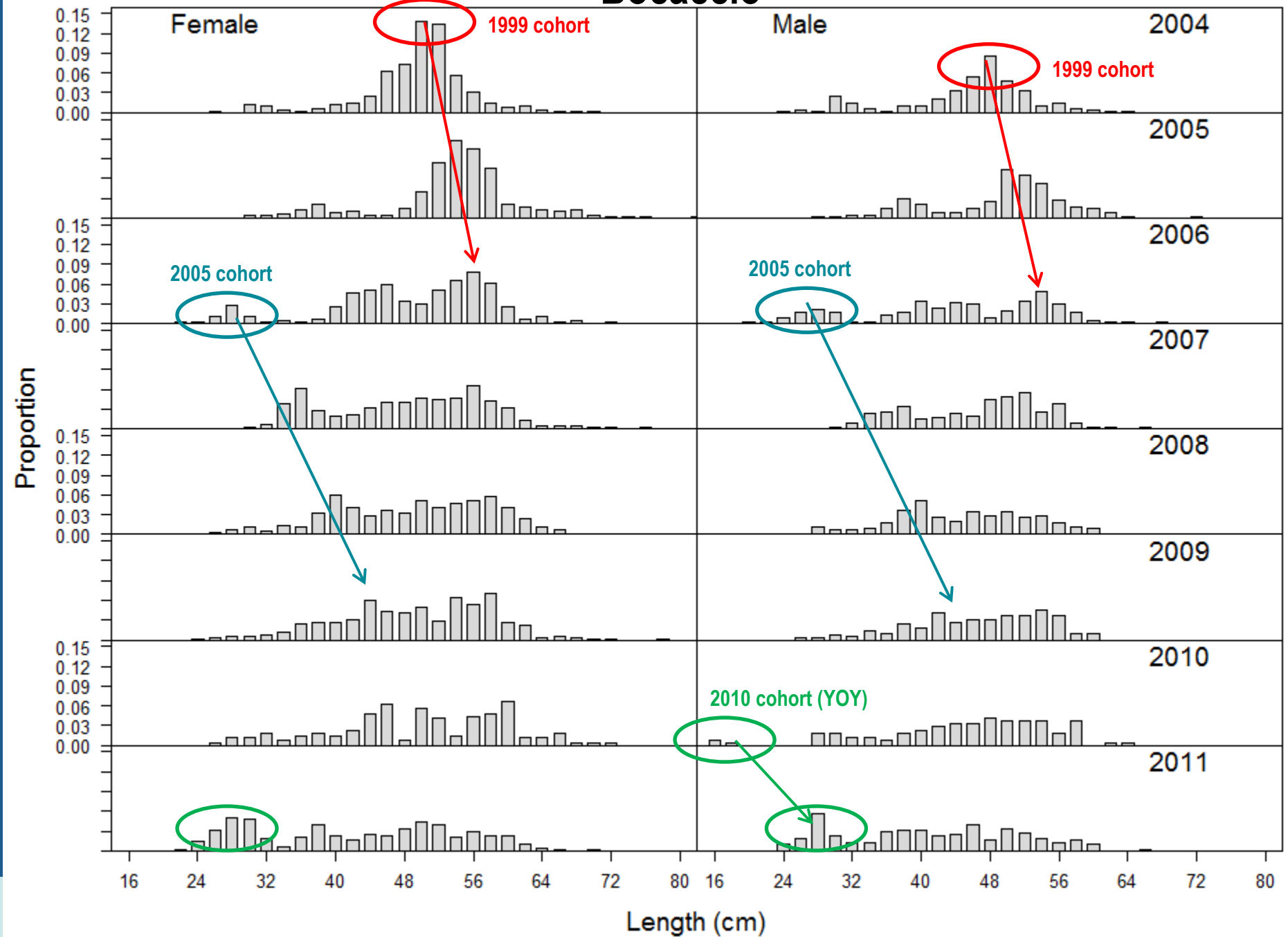
# Summary of hook results

- Fraction of hooks with fish indicates potential to capture either increases or decreases in abundance.
- Changes in Boccaccio abundance have had largest influence

% of hooks returning fish by year



# Bocaccio



# Analysis and Modeling: Applying Survey Data to Stock Assessments

## Objective

- Annual index of abundance for use in stock assessment
- Annual variance estimates reflecting:
  - Parameter (estimation) uncertainty
  - Sampling variability (sites, hooks deployed, weather, etc.)

## Methods

- Variable selection
- GLM structure and Bayesian estimation
- Illustrated here as applied for bocaccio rockfish



# Model selection

## Design-based variables included

Inference	Design
Year	Site*
	Vessel
	Angler
	Drop
	Hook

\* Site is included as a fixed effect, so habitat, depth, location, etc. of the site are not included in the model directly

## Independent variables examined for model selection

Categorical	Continuous
Moon phase	Drift speed
Tide type	Drift direction
Tide phase	Swell height
	Swell direction
	Wave height
	Percent solar day
	Tide height
	Distance to centroid
	Wind speed
	Water temperature



# Link and error model

- Each hook represents a Bernoulli trial:  
**was the species of interest captured?**
- Implies a Binomial error structure

Canonical logit link:  $\mu_{i,j,k,l,m} = \text{logit}^{-1}(\theta_{i,j,k,l,m,n})$

Design variables  $\theta_{i,j,k,l,m,n} = \alpha + \textit{Year} + \textit{Site} + \textit{Vessel} + \textit{Angler} + \textit{Drop} + \textit{Hook}$

Main effects  $+ \textit{Wave height} + \textit{Tide height} + \textit{Tide type}$

2<sup>nd</sup> order polynomials  $+ \textit{Wave height}^2 + \textit{Tide height}^2$

Interaction  $+ \textit{Vessel} \cdot \textit{Tide type}$



# GLM structure (Bocaccio example)

## Design variables

$$\theta_{i,j,k,l,m,n} = \alpha + Year + Site + Vessel + Angler + Drop + Hook$$

## Main effects

+ *Wave height* + *Tide height* + *Tide type*

## 2<sup>nd</sup> order polynomials

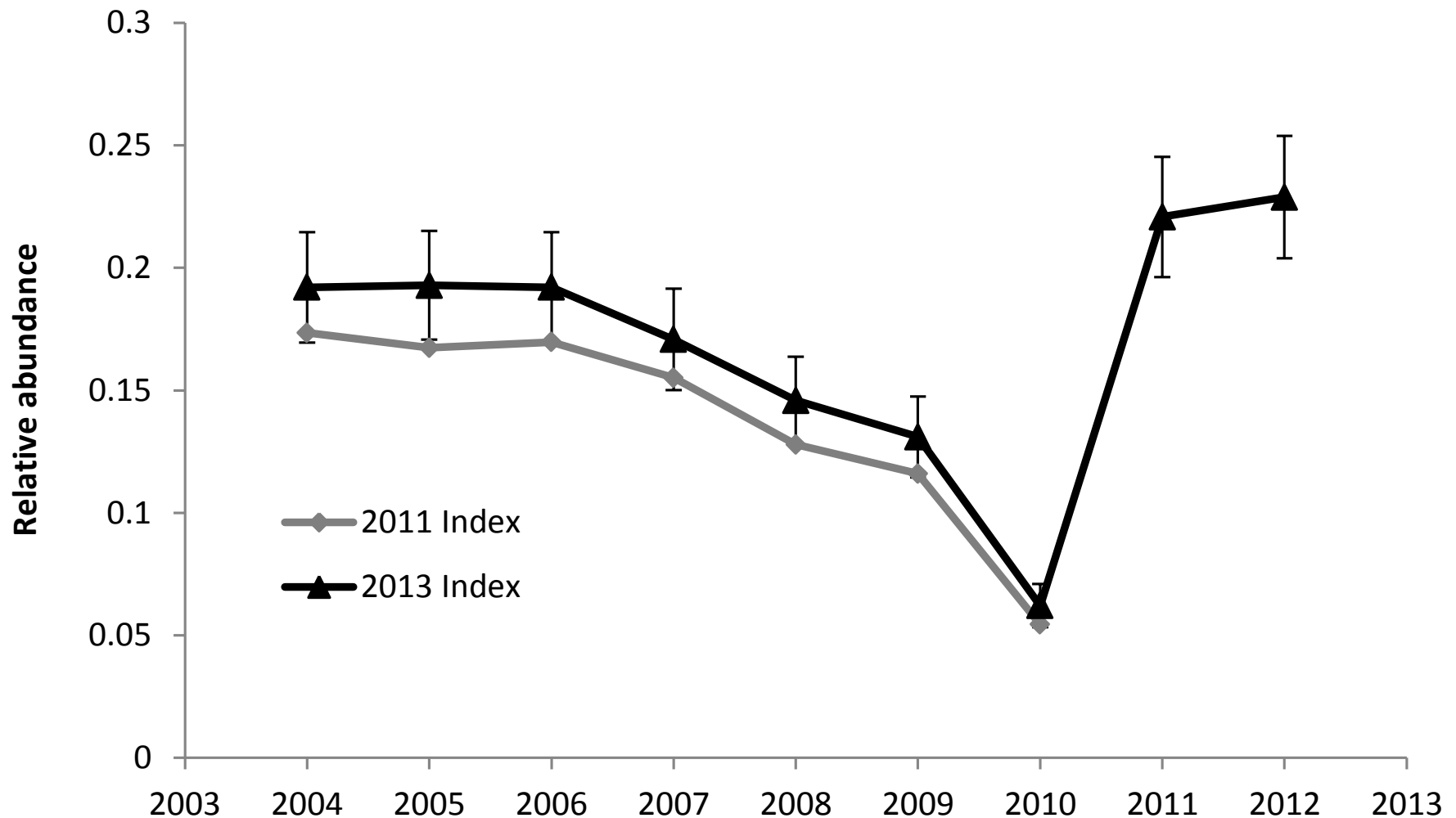
+ *Wave height*<sup>2</sup> + *Tide height*<sup>2</sup>

## Interaction

+ *Vessel* · *Tide type*



# Bocaccio index through 2012





# Index use in stock assessment

- Fixed station design cannot be an absolute estimate of abundance.
  - *Relative catchability must be estimated.*
- Depth range and hook-size potentially cause dome-shaped selectivity.
  - *Largest individuals may be less available to sampling.*
- Over large changes in abundance (currently unobserved), gear may saturate and index may be non-linearly related to biomass
  - *Only likely to occur for high abundance levels well above the precautionary zone.*
- Coherent length- and age-frequency data provide basis for selectivity estimation



# Hook and Line Survey Data Applications

## Stock Assessments

Species	Data provided	Application
<b>Bocaccio</b>	Abundance index; length frequency; length-weight relationship	2009, 2011, and 2013 stock assessments and updates
<b>Vermilion rockfish</b>	Abundance index; ages; length frequency; length-weight relationship	2005 stock assessment and research in conjunction with 2013 data moderate assessments
<b>Cowcod</b>	Abundance index; ages; length frequency; length-weight relationship	2013 stock assessment and research in conjunction with the 2007 and 2009 stock assessments and updates
<b>Greenspotted rockfish</b>	Abundance index; ages; length frequency; length-weight relationship	2011 stock assessment
<b>Yelloweye rockfish</b>	Length-weight relationship	2009 stock assessment
<b>Yellowtail rockfish</b>	Length and weight data; otoliths for ageing	Research in conjunction with 2006 stock assessment
<b>Chilipepper; Yellowtail rockfish</b>	Whole specimens for maturity/fecundity research	Ongoing research into the biology of both species
<b>Blue rockfish</b>	Length and weight data	Research in conjunction with 2007 stock assessment



# Independent Review – April 2012

## Key Design/Methodology Findings

Recommendation/Finding	Action
Randomize angler position assignments	Initiated during 2012 survey
Conduct further examination into the representativeness of sampling sites relative to the region as a whole	Expanding camera sled operations to collect visual seafloor observations at all survey sites for habitat classification
Advised of potential bias associated with indices generated from surveys that include large unsampled areas such as the CCA's	Exploring alternatives that would provide data on important rockfish species while avoiding or minimizing mortality on overfished species





# Stations per scientist-day: 2011

Survey	FRV or Charter	Stations	Scientist-Days	Stations/ Scientist-Days
NEFSC Spring & Fall Trawl Surveys	FRV <i>Bigelow</i>	746	1,714	0.435
SEFSC Spring & Fall Trawl Surveys	FRV <i>Oregon II</i>	409	830	0.493
AFSC Bering Sea/Aleutian Is. Trawl Survey	Commercial charter	1,168	2,112	0.553
NWFSC West Coast Shelf & Slope Trawl Survey	Commercial charter	752	564	1.333
NWFSC Shelf Rockfish Hook & Line (2012)	Sportfishing charter	121	69	1.754



# Hook and Line Survey: Strengths



- Effectively targets habitats not well-sampled by trawl and acoustic surveys
- Provides information on strength of incoming year classes
- Methods are scalable and applicable to areas currently not sampled
- Efficient charter operations minimize costs
- Improved industry-scientist working relationship and a greater sense of buy-in by industry into the research and management process

# Hook and Line Survey: Challenges and Potential Solutions

Challenge	Potential Solution
Limited geographic extent and large excluded areas limit applicability and introduce potential bias in resulting abundance indices	Expand survey coverage into other areas of interest
Expanding into areas not covered increases survey mortality which may be problematic for species with very low annual catch limits (ACLs)	Explore adaptive sampling methods and the use of barotrauma mitigation devices for returning particularly overfished species back to the sea
In areas of very high abundance, gear may saturate and index may become non-linear	Typically occurs at abundance levels well above the precautionary zone; analytical techniques may be able to correct for occasional instances of saturation
Paper data collection and manual data entry is time consuming and can introduce errors into the data	Explore automated data collection methods with integrated QA/QC algorithms



